of the whole book. It contains a full account of thermochemical notation, a selection of the more important data, and an elementary discussion of the law of maximum work. Chemical equilibrium and dissociation are also dealt with, the treatment being non-mathematical, and bearing evidence of the influence of van 't Hoff. The book as a whole forms an admirable introduction to general chemistry; the student who has mastered its contents will have nothing to unlearn, and will be able to proceed at once to the larger text-books of Ostwald and van 't Hoff.

Elementary Hydrostatics. By Charles Morgan, M.A., R.N. Pp. 106. (London: Rivingtons, 1899.)

THIS small text-book contains practically a condensed account of all the leading points in hydrostatics which are usually included in an elementary course, accompanied by an unusually large number of exercises. It makes no attempt at exhaustive treatment, and is rather intended for those studying the subject with tutorial aid. We are sorry to see that the author has gone on the old lines in the dual interpretation of "pressure" as thrust, and also as thrust per unit area, and we should have liked to have seen the notion of "whole pressure" kept in the background, and greater emphasis laid on the use of the formula for the same in obtaining the resultant thrust on a *plane* area. The familiar figure of the air-condenser with the valves resting in their usual impossible upside-down position is here once more reproduced. We like the author's simple treatment of centres of pressure as being instructive and useful to beginners, despite the objections that mathematicians may raise against its validity. For the points which we have criticised, the fault probably lies not so much with the author as with the examinations for which it is his purpose to prepare candidates, and we think that the book will be of great value to all students whose limited time prevents their reading a large treatise. G. H. B.

The Valley of Light.—Studies with Pen and Pencil in the Vaudois Valleys of Piedmont. By W. Basil Worsfold. (London: Macmillan and Co, Ltd., 1899.)

AN author adds to his difficulties by writing a book in the form of letters, especially when he desires to combine instruction with entertainment. Mr. Worsfold has not been more successful than others in overcoming these, and we are not surprised that, as he admits, his fair correspondent found his epistles "not very entertaining." In fact he does not add much to our knowledge of this district. Like his predecessors, he is almost silent on its geology and botany, and devotes himself to the history of the past persecutions and present fortunes of the Waldenses. The former subject is an interesting but hardly a novel one; for it is treated pretty fully in Beattie's "Waldenses" and Gilly's "Narrative." The Waldenses, in fact, have already been the cause of not a few books, if we include those in other tongues than our own, and Mr. Worsfold's does little more than add to their number. We doubt, indeed, whether the best authorities would agree with him in tracing the Waldenses back to early Christian settlements in these valleys, or in the date (twelfth century) which he assigns to the Nobla Leçon. Nothing of special importance seems to have happened in the Waldensian valleys during the last half-century. Their worthy inhabitants have prospered fairly and maintained their high character, but this, though satisfactory, affords but few opportunities to an author. In short, Mr. Worsfold's book has no scientific value, for even the illustrations are poor; and it displays little historical research or originality.

LETTERS TO THE EDITOR.

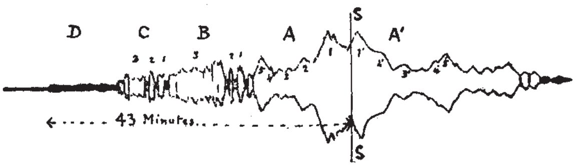
[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Earthquake Precursors.

IN NATURE, February 16 (p. 368), under the title of "Earthquake Echoes," I described the more or less rhythmical series of fading resultants which are seen to succeed many large earthquakes. These earthquake followers, the first of which may sometimes represent the *Uri Kaishi*, or return shaking of the Japanese, are repeated in groups with a decreasing amplitude, an increasing period, and with a smoother and smoother contour. The last of the series may be so small that it is usually difficult to say with certainty when a large earthquake has ceased to exist. As pointed out by Mr. R. D. Oldham, it seems quite possible that certain of the terminal vibrations may have travelled round the world in a direction opposite to that taken by the larger members of the series. The movements to which I now refer are the procession of vibrational groups which run before the main disturbance, with the smaller of which, under the name of preliminary tremors, we are already more or less familiar. These precursors have in several respects characteristics which are exactly the opposite to those of the earthquake followers. They have a definite commencement, and with large earthquakes group after group usually increases suddenly in amplitude and period.

Another feature of the precursors is that, whilst group after group may grow larger, they become more and more larger featured in their contours. The very first of the preliminary tremors have no *frétillements*, or have lost whatever they may have had, whilst those which follow carry serrations which are well marked. This observation, together with that of the growth in amplitude, suggests the idea that the main features of each group of precursors starting from a common origin have reached an observing station by different routes; the first have come along Knott's path of least time, whilst the latter, culminating in the shock, may have travelled along paths continually approximating to that of a free surface-wave.

Now and again, we see in groups of preliminary tremors a likeness in contour and arrangement of what is to follow; but likenesses of this description are perhaps best seen when we compare the shock and its immediate forerunners with the *Uri Kaishi*, or first echo and its successors. Thus, in the accompanying photographic reproduction of the disturbance of June 29, 1898, if we take S S as a line of symmetry, which lines are not uncommon in seismograms, the shock 1 in the group A is preceded by groups of waves 2, 3, 4 and 5, which are not unlike the echoes 1′, 2′, 3′, 4′ and 5′; whilst in the precursors B and C, 1, 2, 3 are not unlike 1, 2, 3. In group D all likenesses are lost. Our knowledge of the very first preliminary tremors like D is less than that of those which follow. Near to an origin they may have a duration of from one or two up to ten or twenty seconds, and their period has been recorded at from 1/5 to 1/20 of a second. When they are preceded by a sound-wave, we have evidence of a very much higher frequency. If these vibrations have travelled long distances and through our earth, most records indicate a period of three or four seconds. Records from Rome have shown periods of less than half a second, but even these are probably much too large. My own records indicate only a slight switching at the end of a light elastic boom or a very rapid to-and-fro motion of the boom relatively to its steady-point. Until a steady-point seismograph with extremely light multiplying indices like that of Vicentini, or some other special form of apparatus, has been employed as a recorder, our knowledge of this end of the seismic spectrum is not likely to increase.



The last points connected with the earthquake precursors are the intervals of time which elapse between the arrival of the first tremor and the largest wave or waves corresponding to the originating impulse and the duration of the very first series of preliminary tremors. As measured on seismograms for disturbances which have originated at different distances from the Isle of Wight observing station, these two intervals are given in the following table :—

Origin.	Distance in degrees.	First P.T. to max. motion in minutes.	Duration of first group of P.T.s in minutes.
Iceland	17	4 or 5	1·4
Greece	22	7	7·0
Tashkent ...	48	15	9·0
Hayti	62	30	13·0
Japan	84	47	8·5
Borneo	112	55	6·0

These figures are too few in number to be used as a foundation for any certain conclusions, but they may possibly indicate results to be sought for in future records. With regard to the first set of intervals, we know that for distances up to 8° from an origin the time by which tremors outrace the main movement may be reckoned by seconds. Adding this fact to our list, it seems that here we have a table which indicates that as an earthquake travels the tremors outrace the large waves at a very slow rate on the first part of its journey; but as its distance from the origin increases, this rate increases. This goes on until a point between 48° and 62° distant from the origin has been reached, after which the rate at which the large movements are left behind decreases.

One explanation for this is to suppose that the first precursors came through the earth with an average velocity which observation shows to increase approximately with the square root of the average depth of the chord joining the centrum and the observing station, whilst the large waves travelled round the surface. An objection to this view is that observations exist which show the large waves have apparently travelled over paths varying between 20° and 110°, at rates which rather than being constant have increased from 2·1 to 3·3 km. per second.

The velocities giving this comparatively slight difference were, however, determined on the assumption that the times at which various earthquakes originated were known, and there is, therefore, a possibility that they may be apparent rather than real.

Also it must be remarked, as pointed out by Dr. C. G. Knott, that if we regard the speed of propagation of the large waves as depending on a coefficient of elasticity, mainly distortional and not appreciably influenced by change of pressure and density, it is quite conceivable that the large waves should also pursue a brachistochronic path through our earth. The question then arises whether these larger movements would be left further and further behind their precursors in the manner indicated.

When we come to our second set of intervals which indicate the duration of the first preliminary tremors before they are eclipsed by groups of vibrations which usually grow in size and appear from their periods to be distortional, we see that up to a point about 62° from an origin these figures increase, but beyond that point they grow less.

What we have to explain in addition to this fact is that of the practical continuity and growth in magnitude of what very often forms a long and continuous series of preliminary motions. As I have already stated, their very appearance indicates that they have travelled on different paths. The first have followed a path entirely through our earth, whilst the successors may have travelled shorter and shorter distances through the earth to meet a crust through which they have completed their journey to the observing station. The first followed Knott's brachistrochronic path, or that of least time, whilst the successors took paths the latter parts of which were along arcs of increasing length. The result of this would be that at an observing station vibrations would arrive in series, each group corresponding to an originating impulse. The last of the rabble would be the series representing the main shock which, although it sent waves on brachistochronic paths, may in part have travelled as a surface undulation through the crust.

To illustrate this hypothesis I here reproduce a sketch given to me by Dr. C. G. Knott, showing the probable form of wave-fronts and paths of compressional vibrations passing through our earth.

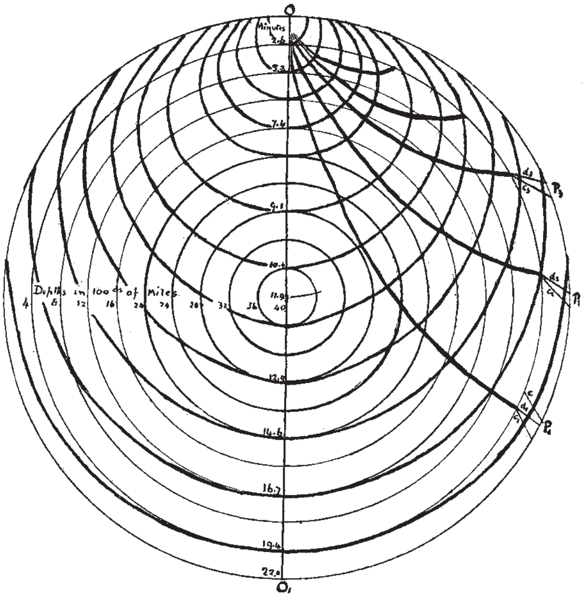
The assumption on which this has been drawn is that the square of the speed of the movements is a linear function of the depth, which closely corresponds, as already indicated, with observation.

The result at which Knott arrives indicates that the square of the speed increases at 0·9 per cent. per mile of descent in the earth, the formula being[1]

$$v^2 = 2{\cdot}9 + {\cdot}026\,d \text{ in mile second units.}$$

With an initial velocity of 1·7 miles per second, the velocities at depths of 400, 800, 1200 . . . 4000 miles become 3·7, 4·9, 5·8, 6·7, 7·4, 8·1, 8·7, 9·3, 9·8, and 10·3 miles per second. The times taken for wave-fronts to reach the positions shown are indicated in the sketch; the time taken to pass through the earth being 22 minutes.

I assume that when a wave has passed from its origin beyond the region vaguely referred to as the crust of our earth, it then spreads in all directions through a mass in which there is only an extremely gradual change in elasticity and density with regard to its centre. All wave-paths, however, before they emerge at the surface, encounter at varying obliquities the under-surface of this crust. For purposes of illustration, we will assume this region of abrupt change to lie on the 400-mile circle. The path p_1 meets this surface nearly at right angles, whilst $p_2\,p_3$ meet it at decreasing angles less than right angles. After each of these incidences a condensational wave will be refracted and split up into condensational and distortional rays. Now it will be observed that these two waves, which I will call c and d, will have different distances to travel before actual emergence, which distances will increase from p_1 towards p_3. At any station P_1 the first arrival will be c, but as this will be eclipsed on the arrival of d, its duration will always be short, and unless the originating shocks are well separated, seismograms, as we know them, can never show more than one set of condensational tremors.



At some point, like p_3, the duration of the preliminary tremors should reach a maximum, but from this point on towards the origin this quantity will decrease, if only on account of the fact that the velocity along the brachistrochronic ray differs less and less from that of the distortional wave within the crust. Such a view may possibly explain not only the short duration of the first precursors, but also the rise and fall in the values of our last column.

The growth in amplitude of the groups of tremors may be due to the fact that they are usually the outcome of originating impulses which increase in intensity until they culminate in a violent shock.

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[1] See *Scottish Geographical Magazine* for January 1899.

As a simple illustration of earthquake radiation, we may imagine a disturbance to originate at O as a single impulse, the resulting vibrations spreading in all directions through the earth, and in all directions over its surface. The former of these may be regarded as elastic vibrations, whilst the latter have the character of surface undulations influenced by gravity. At any station P_1 the first arrivals would be preliminary tremors, chiefly compressional in character. These would be suddenly eclipsed by vibrations, probably distortional, originating by refraction beneath the crust in the vicinity of P_1. The first of them we should expect to find serrated, whilst their followers emerging between P_1 and P_2 would be smoother in outline and larger in amplitude. The last and largest members of the series would be those which have travelled practically as free surface-waves through the crust. The result of such radiation as exhibited on a seismogram would be to show true preliminary tremors, suddenly followed by a series of larger waves, which would gradually grow in size. If at the origin there were several impulses, then these latter precursors would arrive in groups. An alternative hypothesis is to assume that all the vibrations recorded at a station P arrived along their peculiar brachistochronic paths through the earth, an important fact supporting which, is that up to the present we have not with any certainty identified waves which may have reached P passing outwards from O round our world in opposite directions. Although it is not likely that I shall be able, in the tremor-haunted, damp, dark stable where I work, to catch the waves which have taken the longest route to my observing station, that there are such surface undulations radiating in all directions from an epifocal area there is but little doubt. Near to an origin you see the little waves come rolling down a street, whilst at distances of 300 miles the ground swell may be so heavy that I and many others have been seized with nausea. What proportion of seismic energy escapes round the surface of our earth, as compared with that which passes through the same, I do not know; but if the experiment were made, I should not be surprised to find that at the time of large earthquakes, mountains swayed like the masts of ships on a slowly heaving ocean.

All that has here been suggested is clearly very far from being above criticism. It indicates a want of knowledge respecting the researches of the elastician, whilst the facts are few. Although the observations may be characterised by their poverty, I often see in the rough-headed mobs of earthquake precursors rhythmical repetition; and I trust that, if my story of their creation and long duration is not the true one, it may at least induce others to attempt better hypotheses. JOHN MILNE.

The Orbit of Witt DQ.

THE extreme eccentricity of the orbit of Witt's planet suggests some interesting speculations. Assuming the aphelion and perihelion distances in terms of the earth's mean distance are respectively 1·79 and 1·12, the planet approaches the sun in 322 days, a distance of sixty-one million miles, an average of 200,000 miles a day.

Practically this may be considered as a fall, during the half-revolution, of this distance. Now if the planet were a perfectly plastic body, and we knew all its elements, it would be perfectly possible to determine the deforming forces acting on it during the passage. It is evident that the force of gravity acting on the forward point of the syzygial axis would always be in excess of that on the rear, and in consequence that the tendency would be to continually lengthen that axis in a proportion referable to the squares of the distances fallen. On the other hand the force of internal gravitation towards its own centre would always tend to restore the sphericity, and the result would be that a body starting as a sphere from aphelion would find the syzygial axis prolonged and its shape deformed into an increasingly prolate spheroid, till on its arrival at perihelion and its commencement to retreat the reverse phenomenon would occur, and the planet on its return become again a sphere.

Now, of course, we have no reason to suspect that DQ is a plastic body, and the comparative insignificance of its size, would, were it to be composed of matter of equal rigidity with ordinary rocks on the surface of the earth, enable it to successfully resist these deforming influences. We may, however, imagine a case where the strains would be sufficient to break up an ordinarily rigid body, if the eccentricity exceeded a certain amount, and the consequent differential action of gravity became sufficiently great.

A hypothetical planet moving in an orbit of high eccentricity, for instance, between Mars and Jupiter might, so long as it continued plastic, preserve its condition as a single coherent body. If, however, it were cooled to an extent sufficient to become enveloped by a rigid crust, there might come a time when the deforming forces would cause deep and continually proceeding fractures. Eventually we can conceive that these fractures would split the body into fragments, each of which from its own intrinsic rigidity would be able to maintain its shape and cohesion. In such a case each of the fragments would proceed to take up an independent motion of its own. Hence, perhaps, we may see our way, without calling in any extraneous factor, to account for the present zone of asteroids, as well as explain the small size of the individuals.

This tallies, moreover, with observation. The great planets have all orbits approaching a circle; Jupiter, the greatest of all, has, with one exception, the smallest maximum of eccentricity; and Mercury, the smallest, has actually the greatest. The Leonids move in a still more elongated orbit, and they are amongst the smallest celestial objects with which we are acquainted. Altogether the minuteness of the planet and the eccentricity of the orbit have some connection in fact; this connection I cannot believe to be fortuitous, and it seems not altogether presumptuous to refer it to a common law, which we know pervades the universe. This is my excuse for attempting to venture into a hitherto unexplored region of physics, but one pointing to vast possibilities, amongst others in geology.

Shanghai, January 17. THOS. W. KINGSMILL.

The Teaching of Geometry.

I AM sure that all mathematical teachers can thoroughly endorse Prof. Minchin's letter. The difficulty of making a change lies in the University and Civil Service examinations, which still prescribe Euclid. On the continent Euclid has been superseded by modern books, some of which might serve as a basis for a thoroughly reformed English text-book.

I am convinced that the deplorable weakness shown by almost all boys in the solution of geometrical problems, arises in great measure from Euclid; they are utterly confused by its prolixity and verbiage.

And it is not as though this prolixity meant any greater accuracy or better logical sequence. It is not proved till Book iii. that a circle can only cut a straight line in two points; but in (i. 12) this property is quietly assumed, otherwise several perpendiculars could be drawn. I. 13 simply asserts that $a + (b + c) = (a + b) + c$, but is unintelligible to beginners through its verbiage. In i. 16 we practically make an angle equal to the interior one, against the exterior angle, and then ask the pupil to see for himself that one is greater than the other, which is suspiciously like *petitio principii*. In the second Book we have a number of cumbersome proofs, some of which, indeed, are now shortened to an algebraic form. (I have never been able to understand the Cambridge regulation that the sign + may be used, but not the sign −.) The Euclidean definition of proportion is quite unintelligible to beginners, while the conception of similar figures and of *scale* is easily grasped. To insist on young boys entering on the subtleties of the subject, is much as though one made a child beginning arithmetic read, say, the first chapter of Weber's Algebra. What is wanted is thorough ready knowledge of the properties of lines and circles. And for this I would strongly recommend *practical geometry*. I believe it could very easily be made a means of imparting a knowledge of geometry in its highest and widest sense. R. J. DALLAS.

15 Pemberton Gardens, N.

American and English Winters.

WHILE we, in the south of England, this February, have been enjoying weather of extraordinary mildness, we have read in the daily papers of bitter frost in America, and the miseries of a ferocious blizzard. It is by no means uncommon to find opposite winter weather, at the same time, east and west of the Atlantic. Can we form any exact idea as to frequency of the occurrence?

By way of seeking light on this, I have lately compared Chicago and Greenwich weather in the first quarter of the year, in the fifty-one years 1841–91; presenting the facts by a variety of the graphic method, which I do not remember to have seen